US009101287B2

(12) **United States Patent**
Levy et al.

(10) **Patent No.: US 9,101,287 B2**
(45) **Date of Patent: Aug. 11, 2015**

(54) **MULTI CAMERA ENDOSCOPE ASSEMBLY HAVING MULTIPLE WORKING CHANNELS**

(75) Inventors: **Avi Levy**, Herzliya (IL); **Moshe Levi**, Gane Tikva (IL)

(73) Assignee: **Endochoice Innovation Center Ltd.**, Caesarea (IL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 48 days.

(21) Appl. No.: **13/413,252**

(22) Filed: **Mar. 6, 2012**

(65) **Prior Publication Data**

US 2012/0232343 A1 Sep. 13, 2012

Related U.S. Application Data

(60) Provisional application No. 61/449,746, filed on Mar. 7, 2011.

(51) **Int. Cl.**

A61B 1/00	(2006.01)
A61B 1/06	(2006.01)
A61B 1/015	(2006.01)
A61B 1/018	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 1/0615*** (2013.01); ***A61B 1/00177*** (2013.01); ***A61B 1/00181*** (2013.01); ***A61B 1/015*** (2013.01); ***A61B 1/018*** (2013.01); *A61B 1/00091* (2013.01)

(58) **Field of Classification Search**

USPC 600/104, 106, 107, 109–116, 153, 157, 600/158, 160–182; 356/241.1–241.6; 385/117

See application file for complete search history.

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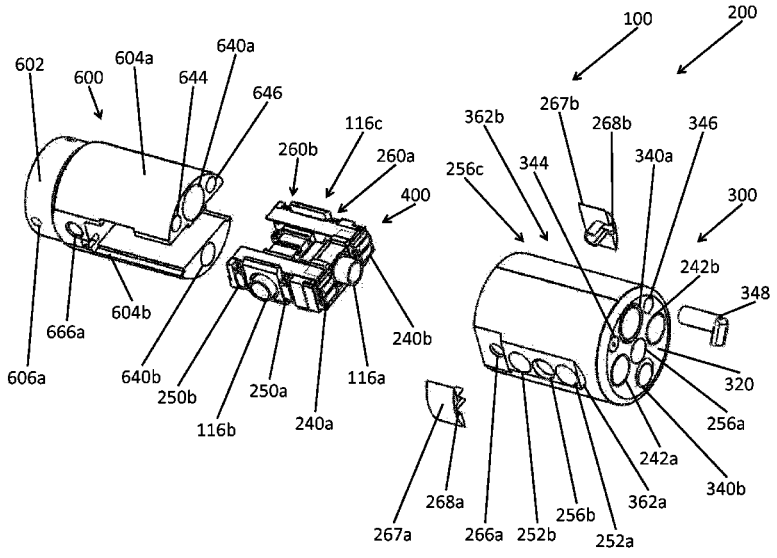
Primary Examiner — Ryan Henderson
(74) *Attorney, Agent, or Firm* — Novel IP

(57) **ABSTRACT**

There is provided herein an endoscope assembly, the assembly comprising at least one front-pointing camera and at least one front illuminator associated therewith, at least one side-pointing camera and at least one of side illuminator associated therewith, a first front working channel configured for insertion of a medical tool and a second front working channel configured for insertion of a medical tool.

24 Claims, 5 Drawing Sheets



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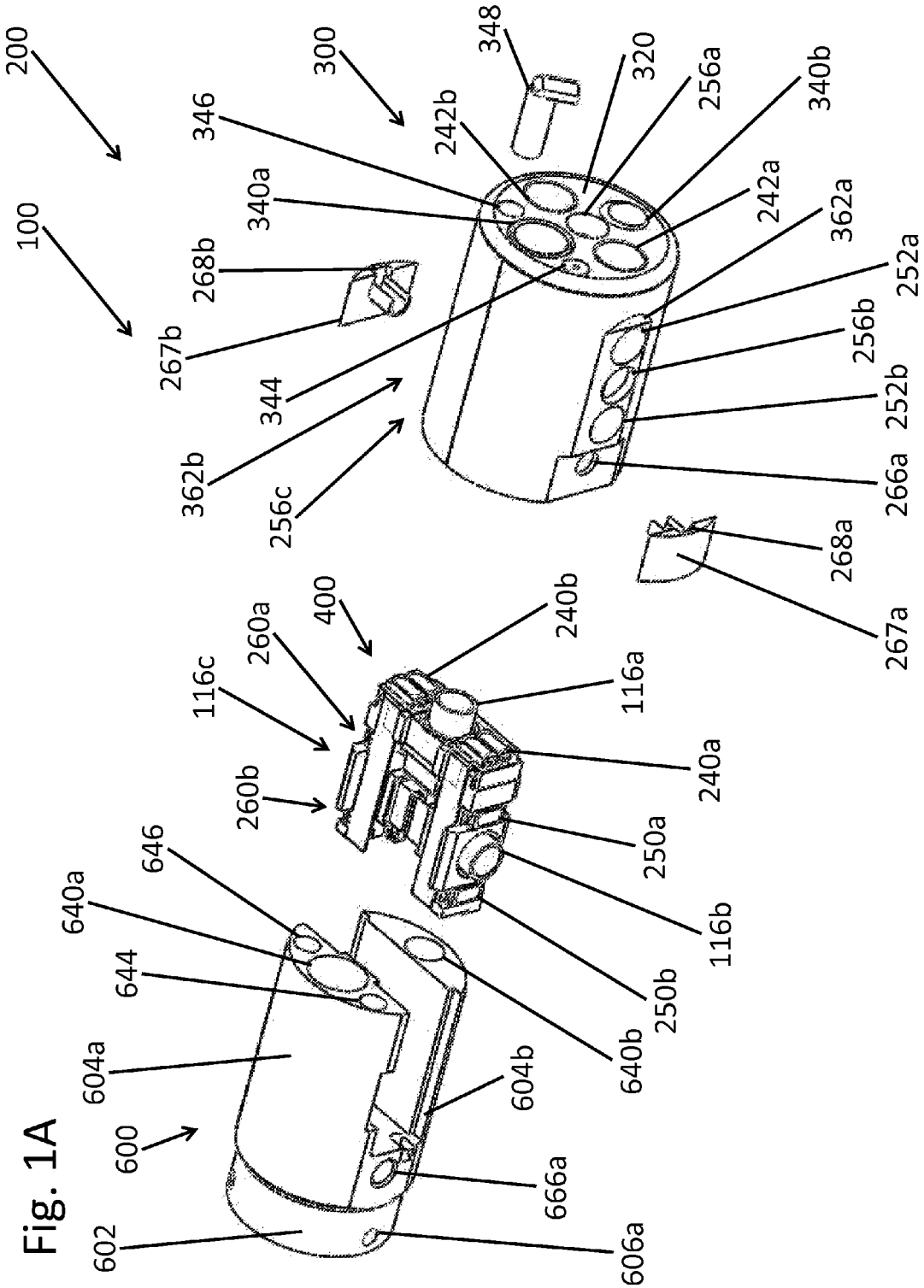
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400
240b
260a
116a
116c
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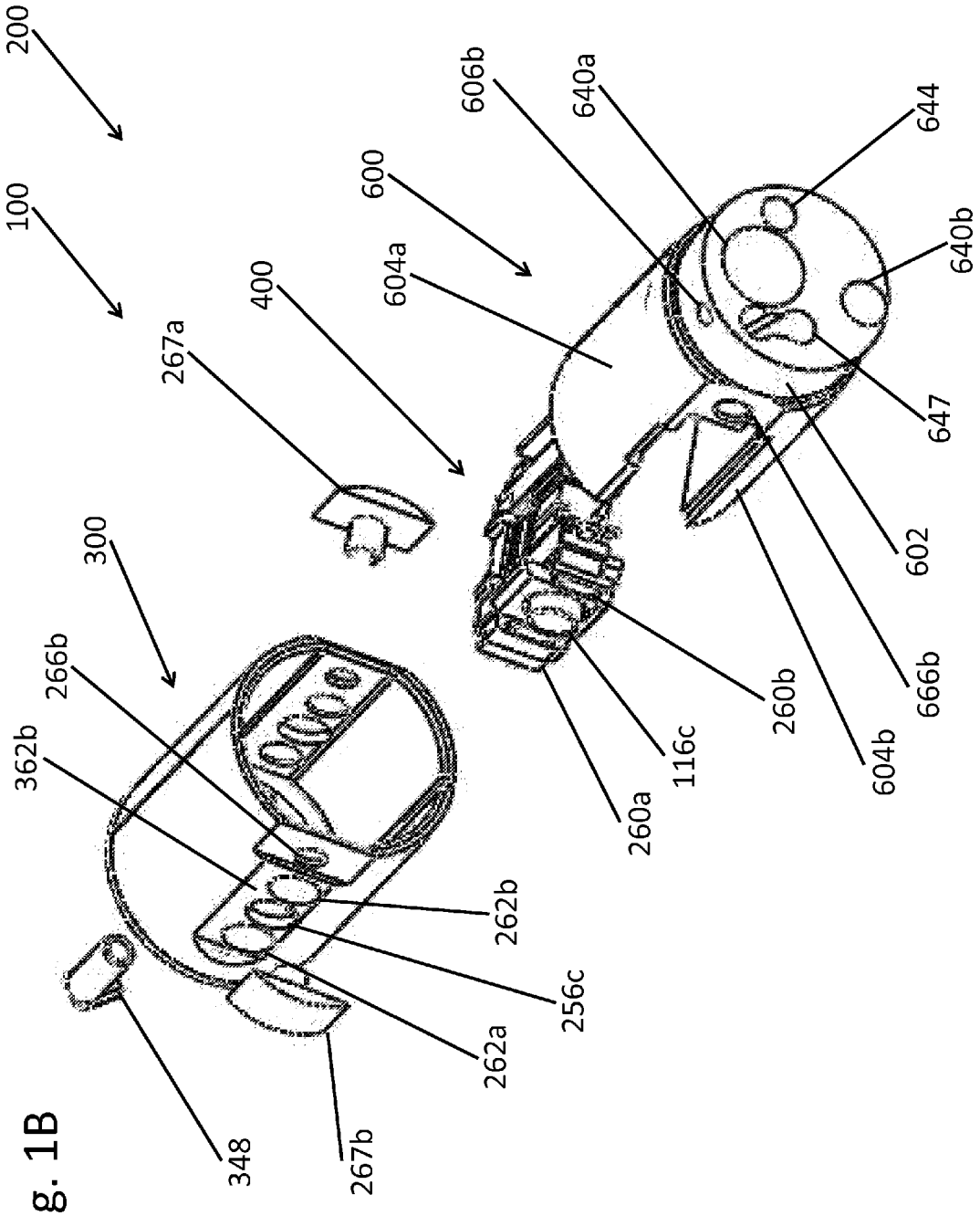
Fig. 1A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348
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Fig. 1B

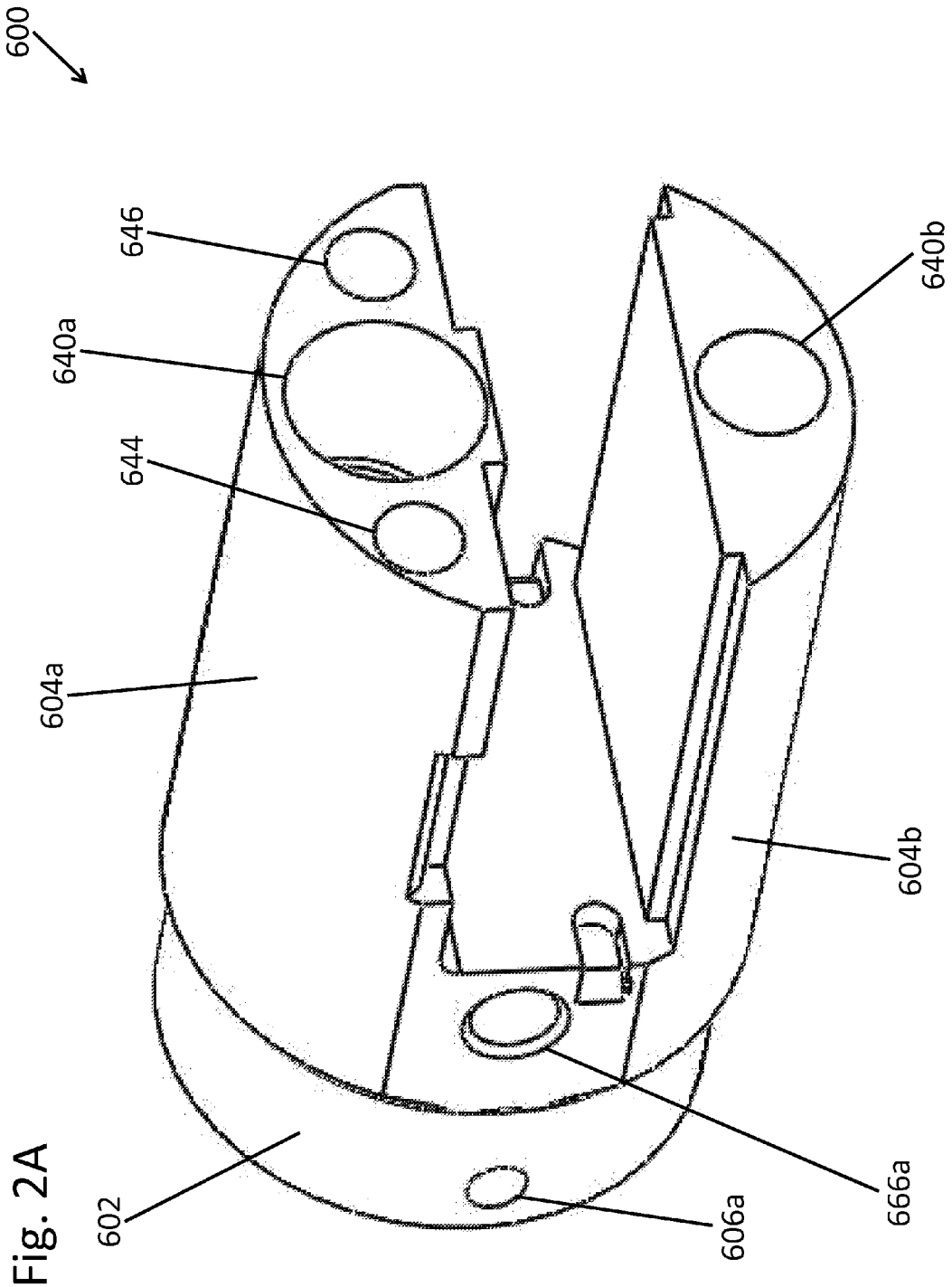

Fig. 2A

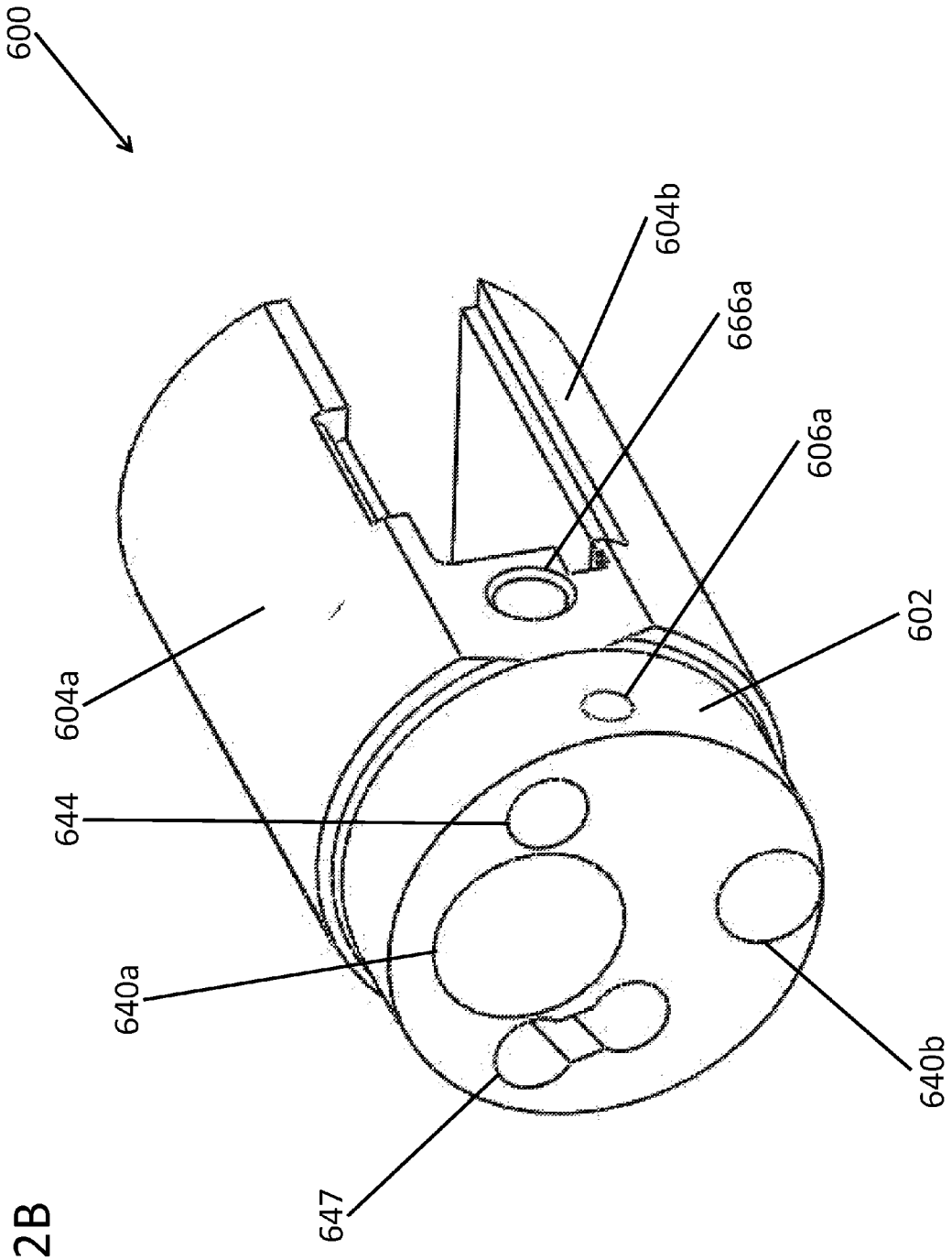

Fig. 2B

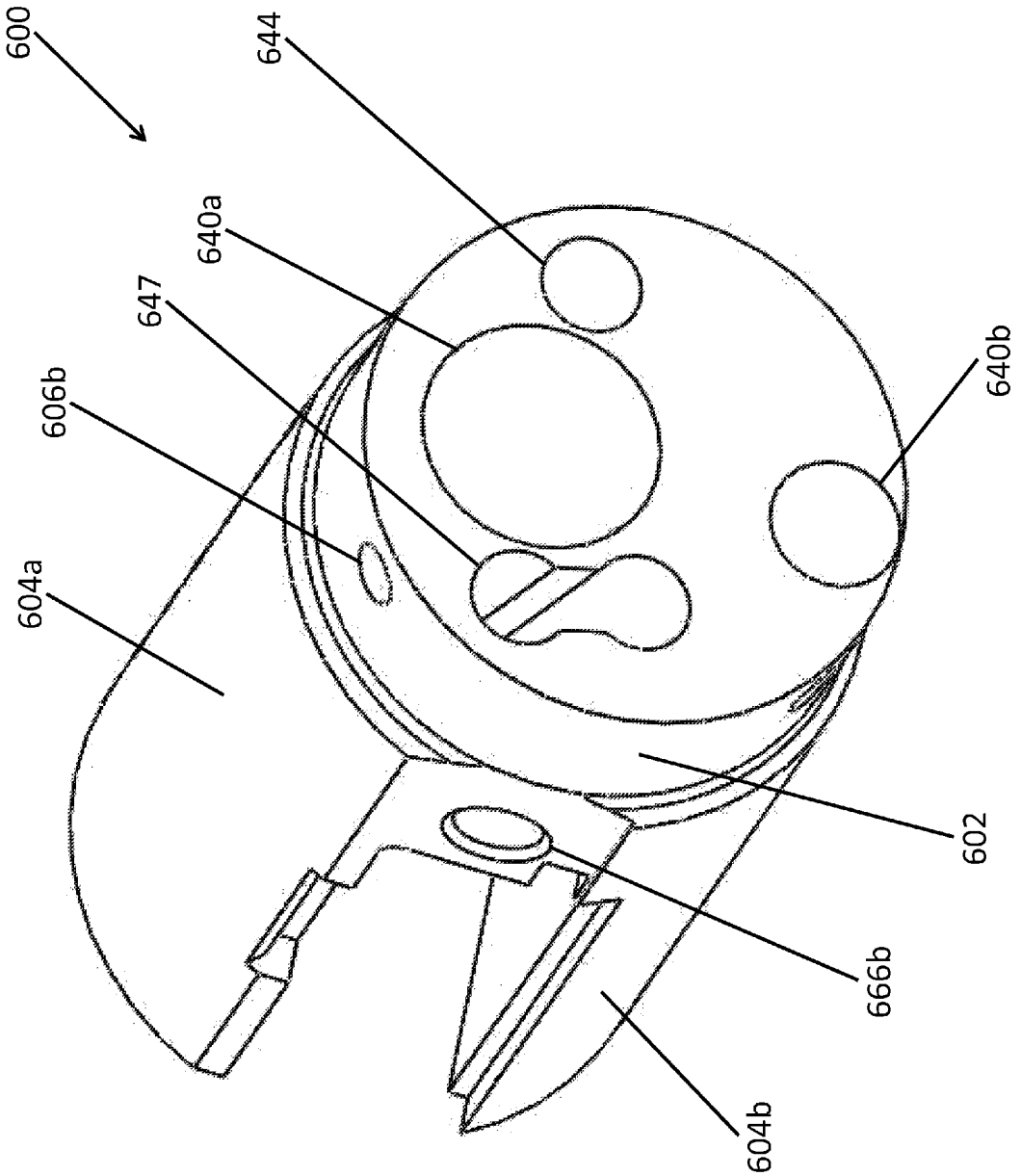

Fig. 2C

MULTI CAMERA ENDOSCOPE ASSEMBLY HAVING MULTIPLE WORKING CHANNELS

REFERENCE TO CO-PENDING APPLICATIONS

Priority is claimed to U.S. Provisional Patent application Ser. No. 61/449,746, filed on Mar. 7, 2011.

FIELD OF THE INVENTION

Embodiments of the invention relate to a multi camera endoscope assembly having two or more working channels.

BACKGROUND

Endoscopes have attained great acceptance within the medical community, since they provide a means for performing procedures with minimal patient trauma, while enabling the physician to view the internal anatomy of the patient. Over the years, numerous endoscopes have been developed and categorized according to specific applications, such as cystoscopy, colonoscopy, laparoscopy, upper GI endoscopy and others. Endoscopes may be inserted into the body's natural orifices or through an incision in the skin.

An endoscope is usually an elongated tubular shaft, rigid or flexible, having a video camera or a fiber optic lens assembly at its distal end. The shaft is connected to a handle, which sometimes includes an ocular for direct viewing. Viewing is also usually possible via an external screen. Various medical tools may be inserted through a working channel in the endoscope for performing different medical procedures.

Endoscopes, such as colonoscopes, that are currently being used, typically have a front camera for viewing the internal organ, such as the colon, an illuminator, a fluid injector for cleaning the camera lens and sometimes also the illuminator and a working channel for insertion of medical tools, for example, for removing polyps found in the colon. Often, endoscopes also have fluid injectors ("jet") for cleaning a body cavity, such as the colon, into which they are inserted. The illuminators commonly used are fiber optics which transmit light, generated remotely, to the endoscope tip section. The use of light-emitting diodes (LEDs) for illumination is also known.

One of the disadvantages of such endoscopes, is their limited access they provide to medical tools, limited field of view and their complicated packing of all the required elements, such as electronics and fiber optics together with fluid carrying elements in the small sized endoscope tip section.

There is thus a need in the art for endoscopes, such as colonoscopies, that allow a broader field of view and allow extended access of medical tools as well as enabling efficient packing of all necessary elements in the tip section, while maintaining their function.

SUMMARY

The following embodiments and aspects thereof are described and illustrated in conjunction with systems, tools and methods, which are meant to be exemplary and illustrative, not limiting in scope.

There is provided herein, according to some embodiments of the invention an endoscope assembly, the assembly comprising: at least one front-pointing camera and at least one front illuminator associated therewith; at least one side-pointing camera and at least one of side illuminator associated therewith; a first front working channel configured for insertion of a medical tool; and a second front working channel configured for insertion of a medical tool.

In some embodiments, the assembly further comprises at least one front fluid injector configured for cleaning at least one of the front-pointing camera and at least one of the front illuminator.

In some embodiments, the assembly further comprises at least one side fluid injector configured for cleaning at least one of the side-pointing camera and at least one of the side illuminator.

In some embodiments, the assembly further comprises a pathway fluid injector for inflating and/or cleaning a body cavity into which the endoscope is inserted.

In some embodiments, the assembly further comprises two side-pointing cameras.

In some embodiments, each of the side-pointing cameras is directed to opposing sides.

In some embodiments, each of the side-pointing cameras is essentially perpendicular to the front camera surface.

In some embodiments, the at least one side-pointing camera forms an obtuse angle with the front camera surface

In some embodiments, the at least one side-pointing camera is forming an acute angle with the front camera surface

In some embodiments, at least one of the front and side illuminators comprises at least one discrete illuminator.

In some embodiments, each of the front and side illuminators comprises a light-emitting diode (LED).

In some embodiments, at least one of the front and side illuminators is configured to emit white light.

In some embodiments, at least one of the front and side illuminators is configured to emit ultraviolet light.

In some embodiments, at least one of the front and side illuminators is configured to emit infrared light.

In some embodiments, at least one of the front and side illuminators is configured to emit near-infrared light.

In some embodiments, the front and side illuminators are configured to emit light in different wavelengths.

In some embodiments, each of the front-pointing camera and the side-pointing camera comprises an image sensor such as, but not limited to, a Charge Coupled Device (CCD) or a Complementary Metal Oxide Semiconductor (CMOS).

In some embodiments, the front and side fluid injectors are connected to a same fluid supply channel.

In some embodiments, the endoscope is a colonoscope. In some embodiments, the endoscope is a flexible endoscope. In some embodiments, the endoscope is a gastroscope.

In some embodiments, fields of view of the front-pointing camera and side-pointing camera are at least partially overlapping.

In some embodiments, at least one of the front and side cameras comprises a lens assembly providing a field of view of 90 degrees or more.

In some embodiments, at least one of the front and side cameras comprises a lens assembly providing a field of view of 120 degrees or more.

In some embodiments, at least one of the front and side cameras comprises a lens assembly providing a focal length of approximately 3-100 millimeters.

In addition to the exemplary aspects and embodiments described above, further aspects and embodiments will become apparent by reference to the figures and by study of the following detailed description.

BRIEF DESCRIPTION OF THE FIGURES

Exemplary embodiments are illustrated in referenced figures. Dimensions of components and features shown in the

figures are generally chosen for convenience and clarity of presentation and are not necessarily shown to scale. It is intended that the embodiments and figures disclosed herein are to be considered illustrative rather than restrictive. The figures are listed below.

FIG. **1**A shows an exploded view of a tip section of an endoscope assembly according to some embodiments;

FIG. **1**B shows an exploded view of a tip section of an endoscope assembly according to some embodiments;

FIG. **2**A shows a perspective view of a fluid channeling component of an endoscope assembly according to some embodiments;

FIG. **2**B shows a perspective view of a fluid channeling component of an endoscope assembly according to some embodiments; and

FIG. **2**C shows a perspective view of a fluid channeling component of an endoscope assembly according to some embodiments.

DETAILED DESCRIPTION

Reference is now made to FIGS. **1**A and **1**B, which show exploded views of a tip section **200** of an endoscope assembly **100** according to an embodiment.

An aspect of some embodiments relates to an endoscope assembly **100** having a tip section **200** equipped with two or more front working channels.

It is noted that the term "endoscope" as mentioned herein may refer particularly to a colonoscope, according to some embodiments, but is not limited only to colonoscopes. The term "endoscope" may refer to any instrument used to examine the interior of a hollow organ or cavity of the body.

It is noted that the term "multi" or "multiple" as mentioned herein may refer to two or more, for example, three, four, five or more.

Tip section **200** may be turnable by way of flexible shaft (not shown) which may also be referred to as a bending section, for example a vertebra mechanism.

According to some embodiments, tip section **200** of an endoscope may include a tip cover **300**, an electronic circuit board assembly **400** and a fluid channeling component **600**.

Electronic circuit board assembly **400** may be configured to carry a front-pointing camera **116***a* and two side-pointing cameras **116***b*, **116***c* which may be similar to front-pointing camera **116***a* and may include a Charge Coupled Device (CCD) or a Complementary Metal Oxide Semiconductor (CMOS) image sensor.

According to some embodiments, side-pointing cameras **116***b* and **116***c* may be installed such that their field of views are substantially opposing. However, different configurations and number of side-pointing cameras are possible within the general scope of the current invention.

Electronic circuit board assembly **400** may be configured to carry front illuminators **240***a*, **240***b*, which may be associated with front-pointing camera **116***a*, may be positioned to essentially illuminate front-pointing camera's **116***a* fields of view.

In addition, electronic circuit board assembly **400** may be configured to carry side illuminators **250***a*, **250***b*, which may be associated with side-pointing camera **116***b* and may be positioned to essentially illuminate side-pointing cameras' **116***b* and side illuminators **260***a*, **260***b*, which may be associated with side-pointing camera **116***c* and may be positioned to essentially illuminate side-pointing cameras' **116***c*.

Front illuminators **240***a*, **240***b* and side illuminators **250***a*, **250***b*, **260***a* and **260***b* may optionally be discrete illuminators and may include a light-emitting diode (LED), which may be a white light LED, an infrared light LED, a near infrared light LED, an ultraviolet light LED or any other LED.

The term "discrete", concerning discrete illuminator, may refer to an illumination source, which generates light internally—in contrast to a non-discrete illuminator, which may be, for example, a fiber optic merely transmitting light generated remotely.

Tip cover **300** may be configured to fit over the inner parts of the tip section **200** including electronic circuit board assembly **400** and fluid channeling component **600** and to provide protection to the internal components in the inner parts.

Tip cover **300** may include a front panel **320** having a front optical assembly **256***a* of front-pointing camera **116***a*. Front optical assembly **256***a* may include a plurality of lenses, static or movable, which may provide a field of view of up to essentially 180 degrees. Front optical assembly **256***a* may provide a focal length of up to about 100 millimeters.

Optical axis of front-pointing camera **116***a* may be essentially directed along the long dimension of the endoscope. However, since front-pointing camera **116***a* is typically a wide angle camera, its field of view may include viewing directions at large angles to its optical axis. Additionally, front panel **320** may include optical windows **242***a* and **242***b* of illuminators **240***a* and **240***b*, respectively. It should be noted that number of illumination sources used for illumination of the field of view may vary.

In addition, front panel **320** may include a working channel opening **340***a* of a working channel **640***a*, and a second working channel opening **340***b* of a second working channel **640***b* which are further discussed below.

Jet channel opening **344** of jet channel **644** may also be located on front panel **320** of tip cover **300**. Jet channel **644** may be configured for providing high-pressure jet of fluid such as water or saline for cleaning the walls of the body cavity.

Also located on front panel **320** of tip cover **300** is injector opening **346** of injector channel **646** having a nozzle **348** aimed at front optical assembly **256***a*.

Injector channel **646** may be fed by a fluid or fluid blend such as water and/or gas and configured for injecting fluid blend (liquid and/or gas) to wash contaminants such as blood, feces and other debris from front optical assembly **256***a* of front-pointing camera **116***a*. In addition, the fluid blend may include gas, which may be used for inflating a body cavity.

Optionally, injector channel **646** may be configured for cleaning front optical assembly **256***a* and one, two or all of optical windows **242***a* and **242***b*.

A sidewall **362***a* of tip cover **300** may include an optical assembly **256***b* for side-pointing camera **116***b*, which may be similar to front optical assembly **256***a* and optical windows **252***a* and **252***b* of illuminators **250***a* and **250***b* for side-pointing camera **116***b*.

A sidewall **362***b* of tip cover **300**, which may be similar to sidewall **362***a* and located on the opposite side of tip cover **300**, may include an optical assembly **256***c* for side-pointing camera **116***c*, which may be similar to front optical assembly **256***a* and optical windows **262***a* and **262***b* of illuminators **260***a* and **260***b* for side-pointing camera **116***b*.

Optical axis of side-pointing cameras **116***b* and **116***c* may be essentially directed perpendicular to the long dimension of the endoscope. However, since side-pointing cameras **116***b* and **116***c* are typically a wide angle camera, its field of view may include viewing directions at large angles to its optical axis.

According to some embodiments, side injector channels **666***a* and **666***b* may be configured to supply fluids for clean-

ing any of the tip elements (such as any optical assembly, windows, illuminators, and other elements). Side injectors opening **266***a* and **266***b* of side injector channels **666***a* and **666***b* may be located at distal end of sidewalls **362***a* and **362***b* respectively. Nozzle covers **267***a* and **267***b* may be configured to fit side injectors opening **266***a* and **266***b*.

Additionally, nozzle covers **267***a* and **267***b* may include nozzles **268***a* and **268***b* which may be aimed at side optical assembly **256***b* and **256***c* and configured for injecting a fluid or fluid blend to wash contaminants such as blood, feces and other debris from side optical assembly **256***b* and **256***c* of side-pointing camera **116***b* and **116***c*. Optionally, nozzles **268***a* and **268***b* may be configured for cleaning side optical assembly **256***b* and **256***c* and optical windows **252***a*, **252***b*, **262***b* and/or **262***b*.

Optionally, injector channel **646** and side injector channels **666***a* and **666***b* may be fed from same channel.

It is noted that according to some embodiments, the endoscope tip may include more than one optical window and illuminators on the side and more than one optical window and illuminators on the front.

Sidewalls **362***a* and **362***b* may have a form of an essentially flat surface, which assists in directing the cleaning fluid injected from injector channel **666***a* and **666***b* towards side optical assembly **256***b* and **256***c* and optical windows **252***a*, **252***b*, **262***a* and/or **262***b*. Lack of such flat surface may result in dripping of the cleaning fluid along the curved surface of tip section **200** of the endoscope without performing the desired cleaning action.

Reference is now made to FIGS. **2**A, **2**B and **2**C which show a perspective views of a fluid channeling component **600** of an endoscope assembly **100** according to an embodiment.

According to some embodiments, fluid channeling component **600** may be configured as a separate component from electronic circuit board assembly **400** (FIG. **1**). This configuration may be adapted to separate the fluid channels and working channels **640***a* and **640***b*, which are located in fluid channeling component **600** from the sensitive electronic and optical parts which may be located in the area of electronic circuit board assembly **400** (FIG. **1**).

According to some embodiments, fluid channeling component **600** may include a Proximal fluid channeling section **602** which may have an essentially cylindrical shape, a primary distal channeling section **604***a* and a secondary distal channeling section **604***b*. Primary distal fluid channeling section **604***a* and secondary distal channeling section **604***b* may partially continue the cylindrical shape of proximal fluid channeling section **602** and may have a shape of a partial cylinder (optionally elongated partial cylinder). Primary distal fluid channeling section **604***a* and secondary distal channeling section **604***b* may form solely two parallel fractions of the cylinder (along the height axis of the cylinder), wherein the third fraction of the cylinder (along the height axis of the cylinder) is missing. Primary distal fluid channeling section **604***a* and secondary distal channeling section **604***b* may be integrally formed as a unitary block with proximal fluid channeling section **602**. The height of primary distal fluid channeling section **604***a* and secondary distal channeling section **604***b* may by higher than that of proximal fluid channeling section **602**. In the case of primary distal fluid channeling section **604***a* and secondary distal channeling section **604***b* may have the shape of the partial cylinder (for example, partial cylinder having only a fraction of a cylinder shape along one side of the height axis) and provide a space to accommodate electronic circuit board assembly **400** (FIG. **1**).

Proximal fluid channeling section **602** may include integrated screw nuts **606***a* and **606***b*, which may be configured for securing tip section **200** (FIG. **1**) to the endoscope shaft (not shown).

Reference is now made back to FIGS. **1**A and **1**B. Tip section **200** may include a front-pointing camera **116***a* as well as side-pointing cameras **116***b* and **116***c*. While front-pointing camera **116***a* may be able to detect objects of interest (such as a polyp or another pathology), based on front-pointing camera's **116***a* field of view, side-pointing camera may be able to detect additional objects of interest which are normally hidden from the front-pointing camera **116***a*.

Reference is now made back to FIGS. **2**A, **2**B and **2**C. Primary distal fluid channeling section **604***a* may include working channel **640***a* having a working channel openings **340***a*, which may be configured for insertion of a medical (such as a surgical) tool, for example, to remove, treat and/or extract a sample of the object of interest found in the colon or its entirety for biopsy.

Working channel **640***a* may be formed as an essentially cylindrical channel located within primary distal channeling section **604***a* along the long dimension of the endoscope and placed in parallel to primary distal fluid channeling section **604***a*.

Once an object of interest has been detected, endoscope operator may desire to insert one or more medical tools and remove, treat and/or extract a sample of the polyp or its entirety for biopsy. Therefore, it may be beneficial for the endoscope's operator to be able to use more than one medical tool.

Advantageously, secondary distal channeling section **604***b* may include a second working channels **640***b* having a working channel opening **340***b* which may be similar to working channel **640***a* and may be configured for insertion of a medical tool, for example but not necessarily, in addition to the medical tool which may be inserted through working channel **640***a*. The operator may also choose from which working channel he or she would like to insert the medical tool, for example according to the position of the polyp.

Second working channel **640***b* may be formed as an essentially cylindrical channel located within secondary distal channeling section **604***b* along the long dimension of the endoscope and placed in parallel to secondary distal channeling section **604***b*. Other configurations may also be possible. First and second working channels may be the same or different in shape and size.

Second working channel **640***b* may be configured to improve the performance of the endoscope (particularly, the colonoscope). Current colonoscopes typically have one working channel, which opens at the front distal section of the colonoscope. Such front working channel is adapted for insertion of a surgical tool. The physician is required to perform all necessary medical procedures, such as biopsy, polyp removal and other procedures, via this one channel.

According to some embodiments of this invention, there is provided herein an endoscope (such as colonoscope) that includes (in a tip section thereof), in addition to a front camera and one or more side cameras, and in addition to a front working channel, also a second front working channel that is configured for insertion of a medical (such as a surgical) tool, optionally in addition to a medical tool inserted from the front working channel.

A second working channel, such as second working channel **640***b* allows greater flexibility to the endoscope operator and allow the insertion of medical tools in addition to (or instead of) the medical tools which may be inserted through working channel **640***a*.

This may significantly improve the performance of the endoscope and allow the endoscope operator to perform more complex medical procedures using two medical tools. Second working channel **640***b* provides the endoscope operator a better access to the object of interest and greater flexibility with operating the medical tools while at the same time viewing the procedure by the front pointing camera **116***a* (FIG. **1**). This substantially increases the performance of the endoscope. Moreover, the two front working channels may be used simultaneously for medical procedures. An example of such procedure may include surgery that requires stitching which can more easily be performed using two tools from two channels.

Another example of simultaneous usage of two working channels may include cleaning of the colon. A common problem exists when physicians find out that the patient's colon is not sufficiently clean. In such cases, the physician can try to clean the colon part using the "jet" exiting from the front part of the tip and in bad cases the physician is forced to send the patient home and reschedule his/her appointment. According to embodiments of the invention, the two channels can be used simultaneously for cleaning. For example, a cleaning fluid (such as water or water with air) may be inserted through one working channel and suctioned out from a second working channel. This may allow a better cleaning procedure that may solve or mitigate the problem of less efficient colonoscopies due to a non-cleaned colon.

In addition, a colonoscopy performed using a colonoscope according to embodiments of the invention may save the need of a cleaning procedure, currently performed by the patient him/herself, prior to colonoscopy.

Distal fluid channeling section **604** may further include a jet fluid channel **644** which may be configured for providing high pressure jet of fluid such as water or saline for cleaning the walls of the body cavity (such as the colon) and optionally for suction. Distal fluid channeling section **604** may further include a injector channel pathway **647** of injector channel **646**, which may be used for blending two fluids (like air and water) and convey the fluid blend into injector channel **646** which may be configured to inject the fluid blend and wash contaminants such as blood, feces and other debris from front optical assembly **256***a* (FIG. **1**) of front-pointing camera **116***a* (FIG. **1**).

Proximal fluid channeling section **602** of fluid channeling component **600** may include side injector channels **666***a* and **666***b*, which may be connected to side injectors opening **266***a* and **266***b* (FIG. **1**) respectively.

While a number of exemplary aspects and embodiments have been discussed above, those of skill in the art will recognize certain modifications, permutations, additions and sub-combinations thereof. It is therefore intended that the following appended claims and claims hereafter introduced be interpreted to include all such modifications, permutations, additions and sub-combinations as are within their true spirit and scope.

In the description and claims of the application, each of the words "comprise" "include" and "have", and forms thereof, are not necessarily limited to members in a list with which the words may be associated.

What is claimed is:

1. An endoscope assembly, the assembly comprising:

a substantially cylindrical fluid channeling component having a length and a height, the fluid channeling component having, along said height, a first fraction and a second fraction, wherein:

the first fraction extends outward along the length of the fluid channeling component, and comprises a housing that has encased therein a working channel extending along the length of said fluid channeling component, and the second fraction is a void;

an electrical assembly configured to fit within said second fraction, wherein the electrical assembly comprises an integrated circuit board having mounted thereon a front-pointing camera, a first side-pointing camera, and a second side-pointing camera; and

two front illuminators positioned adjacent the front-pointing camera, two first side illuminators positioned adjacent the first side-pointing camera, and two second side illuminators positioned adjacent the second side-pointing camera;

a tip cover section configured to be removably attachable to said fluid channeling component and configured to receive said electrical assembly, wherein the tip section comprises a front working channel configured to mate to said working channel of the fluid channeling component and provide a contiguous pathway for receiving a medical tool, optical windows configured to mate to said two front illuminators, optical windows positioned along a first side of the tip section and configured to mate to said two first side illuminators, and optical windows positioned along a second side of the tip section and configured to mate to said two second side illuminators.

2. The assembly according to claim **1**, further comprising at least one front fluid injector configured for cleaning at least one of said front-pointing camera and at least one of said front illuminators.

3. The assembly according to claim **1**, further comprising at least one side fluid injector configured for cleaning at least one of said side-pointing cameras and at least one of said side illuminators.

4. The assembly according to claim **1**, further comprising a pathway fluid injector for inflating and/or cleaning a body cavity into which the endoscope is inserted.

5. The assembly according to claim **1**, wherein said side-pointing cameras are directed to opposing sides.

6. The assembly according to claim **1**, wherein each of said side-pointing cameras are essentially perpendicular to a surface of said front camera.

7. The assembly according to claim **1**, wherein at least one of the side-pointing cameras forms an obtuse angle with said front camera.

8. The assembly according to claim **1**, wherein at least one of the side-pointing cameras forms an acute angle with said front-pointing camera.

9. The assembly according to claim **1**, wherein at least one of said front and side illuminators comprises at least one discrete illuminator.

10. The assembly according to claim **9**, wherein each of said front and side illuminators comprises a light-emitting diode (LED).

11. The assembly according to claim **1**, wherein at least one of said front and side illuminators is configured to emit white light.

12. The assembly according to claim **1**, wherein at least one of said front and side illuminators is configured to emit ultraviolet light.

13. The assembly according to claim **1**, wherein at least one of said front and side illuminators is configured to emit infrared light.

14. The assembly according to claim **1**, wherein at least one of said front and side illuminators is configured to emit near-infrared light.

15. The assembly according to claim **1**, wherein said front and side illuminators are configured to emit light in different wavelengths.

16. The assembly according to claim **1**, wherein each of said front-pointing and side-pointing cameras comprises an image sensor.

17. The assembly according to claim **1** further comprising a front fluid injector and a side fluid injectors connected to a same fluid supply channel.

18. The assembly according to claim **1**, wherein said endoscope is a colonoscope.

19. The assembly according to claim **1**, wherein said endoscope is a flexible endoscope.

20. The assembly according to claim **1**, wherein said endoscope is a gastroscope.

21. The assembly according to claim **1**, wherein fields of view of said front-pointing and side-pointing cameras are at least partially overlapping.

22. The assembly according to claim **1**, wherein said at least one of said front and side-pointing cameras comprises a lens assembly providing a field of view of 90 degrees or more.

23. The assembly according to claim **1**, wherein said at least one of said front and side-pointing cameras comprises a lens assembly providing a field of view of 120 degrees or more.

24. The assembly according to claim **1**, wherein said at least one of said front and side-pointing cameras comprises a lens assembly providing a focal length of approximately 3-100 millimeters.

* * * * *